*U.S. Department of Transportation*
*Federal Aviation Administration*
*Office of Aviation Policy and Plans*

# PRELIMINARY REGULATORY EVALUATION, INITIAL REGULATORY FLEXIBILITY DETERMINATION, TRADE IMPACT ASSESSMENT, AND UNFUNDED MANDATES ACT DETERMINATION

# IMPROVED FLAMMABILITY STANDARDS FOR THERMAL/ACOUSTIC INSULATION MATERIALS USED IN TRANSPORT CATEGORY AIRPLANES

## PARTS 25, 91, 121, 125, AND 135

**AIRCRAFT REGULATORY ANALYSIS BRANCH, APO-320**

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## I. INTRODUCTION AND BACKGROUND

This regulatory evaluation examines the impacts of a proposed rule to amend the flammability standards for thermal/acoustic insulation materials used in transport category airplanes. A proposed new flammability test method and criteria for flame propagation would apply to airplanes of new type designs and to newly manufactured airplanes of previously approved designs entering parts 91, 121, 135, and 125 service. A proposed new fuselage flame penetration test method and criteria would also apply to airplanes of new type designs and newly manufactured airplanes of previously approved designs entering part 121 service, if those airplanes have a passenger capacity of 20 or greater.

Insulation blankets are typically composed of a batting (glass fiber, such as Owens Corning's Fiberglass®) and a film covering to contain the batting and resist moisture penetration. Commonly used films include DuPont's metalized and nonmetalized Mylar® (a polyethylene terephthalate or PET) and Tedlar® (a polyvinyl fluoride or PVF). Irrespective of the film type, there are variations associated with its assembly that result in differences in performance from a safety standpoint. These variations include the density of the film, the type and fineness of the scrim bonded to the film, and the adhesive used to bond the scrim to the film.

Thermal/acoustic insulation can impact fire safety in two ways. First, due to its location behind interior panels, insulation blankets can provide a path for flame propagation. The current certification test attempts to address this issue by requiring that insulation be self-extinguishing after exposure to a Bunsen burner flame (see Appendix F to part 25 of the Federal Aviation Regulations (FAR's)). Second, insulation blankets can provide protection against fuselage penetration or burnthrough[1] from an external, post-crash fire. Although there are no current requirements for fuselage burnthrough, the FAA has determined that improving thermal/acoustic insulation can extend the time between a crash and penetration of the cabin by an external fire, affording survivors more time to evacuate the airplane.

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[1] Burnthrough refers to an external fuel fire that penetrates three fuselage shell members: aluminum skin, thermal/acoustical insulation, and the sidewall panel/cabin flooring.

Over the past 25 years, based on research conducted by the FAA's Technical Center, the FAA has adopted improved flammability standards for seat cushions, large interior panels, and cargo compartment liners. In February 1998 the FAA required detection and suppression equipment for the majority of cargo compartments used in the transport category fleet. Although these improvements provide additional fire protection, none addressed what could be the first source of fuel for a fire, that of the thermal/acoustic insulation.

The Fire Safety Section at the Technical Center has been investigating fuselage burnthrough since the late 1980's, prompted by an accident in Manchester, England, in 1985, when 55 fatalities occurred due to the rapid burnthrough from an external, post-crash fire. The FAA, in conjunction with the Civil Aviation Authority (CAA) of the United Kingdom and the Direction Generale de l'Aviation Civile (DGAC) of France, has conducted research to assess the capability of aircraft fuselages to resist burnthrough from an external fuel fire. This research demonstrated the importance of thermal/acoustic insulation in the burnthrough process and showed that the simplest and most effective method of improving burnthrough resistance was to improve the fire resistance of the insulation.

The FAA is aware of several incidents of fires in which the flammability characteristics of thermal/acoustic insulation material may have been a contributing factor.[2] In November of 1993, a fire occurred in a McDonnell Douglas MD-87 airplane while it was taxiing in from a landing at Copenhagen, Denmark. The fire was found to have been initiated by an electrical fault behind a sidewall, but investigators later determined that the insulation materials contributed to the propagation of the fire. In November of 1995, a cabin fire occurred in a McDonnell Douglas MD-82 airplane prior to takeoff at

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[2] Other accidents and incidents are discussed in Chapter IV.

Turin, Italy. The cause of the fire was attributed to a ruptured lighting ballast. In that case, other interior materials played a more significant role in propagating the fire, but there was evidence that the fire also propagated on the film of the insulation.

In June of 1996, the FAA received a letter from the Civil Aviation Authority of China (CAAC), which described three incidents of interior fires that occurred in China in 1994 and 1995. Those incidents involved McDonnell Douglas and Boeing airplanes, and were caused by electrical problems or inappropriate maintenance actions. In each of those cases, damage to the airplane was minimal, but there was clear evidence that the fires had propagated on the insulation.

In response to this information, the FAA increased its efforts to determine whether the current (Bunsen burner) certification test method was adequate. In conjunction with the International Aircraft Materials Fire Test Working Group (IAMFTWG), the FAA also examined a test method currently employed by the aviation industry, the “cotton-swab” test. The results of this program showed that the cotton-swab test provided better discrimination between materials than did the current Bunsen burner certification test method. Additional, larger-scale investigations to determine whether the cotton-swab test was adequate showed that, although there were materials that could pass the cotton-swab test, these materials would propagate a flame in a large-scale environment. Based on these results, the FAA concluded that neither the current certification test method nor the cotton-swab test method was satisfactory and that a new flammability test method was required.

As a result of this research, the FAA has identified two new test methods, one that addresses burnthrough and one that addresses flame propagation. The applicability of these test methods to the existing fleet and to newly manufactured airplanes is discussed below.

## II. DISCUSSION OF THE PROPOSED RULE

The FAA proposes to amend the current regulations as follows:

Part 25: The FAA proposes to adopt the new test methods as new Part VI and VII requirements to Appendix F. The proposed requirements are new flammability test standards that would be applied to thermal/acoustic insulation, in lieu of the current standard. This proposal also includes the adoption of a new § 25.856, which would address thermal/acoustic insulation materials wherever they may be installed.

All new part 25 designs would be subject to the flame propagation requirements.

For new designs with passenger capacities of 20 or greater, the proposed new flame penetration (burnthrough) test method would apply to the insulation as installed in the lower half of the airplane, the area considered to be the most susceptible to penetration by an external fire.[3] New designs with passenger capacities of fewer than 20 would be exempt from the proposed burnthrough requirement because smaller transport category airplanes and those operating in an all-cargo mode would not realize a significant benefit from enhanced burnthrough protection, owing to their rapid evacuation capability from a favorable exit-to-passenger ratio.

Part 121: For transport category airplanes manufactured after two years after the effective date of the rule, the FAA proposes to require installation of materials meeting the new flame propagation requirements of part 25. For airplanes manufactured after four years after the effective date, the FAA proposes to require installation of materials

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[3] The means intended to be utilized for fastening the insulation to the fuselage must be accounted for when performing tests. The FAA is developing advisory material concerning the installation of insulation that will enable the installer to avoid a specific test on the fasteners.

meeting both the new flame propagation and burnthrough requirements, except that transport category airplanes with fewer than 20 seats would not be required to meet the burnthrough requirements.

In addition, for all other transport category airplanes, when thermal/acoustical insulation materials are installed as replacements after two years after the effective date, those materials would have to meet the flame propagation requirements of the proposed rule.[4]

Parts 91, 125, and 135: The proposed rule would apply to transport category airplanes type certificated after January 1, 1958. For airplanes manufactured after two years after the effective date of the final rule, thermal/acoustic insulation materials would be required to meet the proposed flame propagation requirements of part 25. When thermal/acoustical insulation materials are installed as replacements after two years after the effective date, those replaced materials would be required to meet the proposed flame propagation requirements.

## III. COSTS OF THE PROPOSED RULE

The following analysis is based on information received from airplane manufacturers, operators, and insulation blanket manufacturers. Testing results at the FAA's Technical Center show that insulation materials are commercially available that will meet the FAA's proposed requirements for both flame propagation and burnthrough. The estimates presented below are preliminary and may overstate the actual material costs to affected operators, because other, less expensive materials may be developed, as the proposed tests become known. The FAA solicits information from

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[4] The FAA is developing proposed Airworthiness Directives to retrofit those Douglas airplanes equipped with metalized Mylar®. The cost of these AD's added to the cost of this NPRM would not change the cost-benefit conclusion of this NPRM.

manufacturers, air carriers, and insulation blanket manufacturers to refine these estimates.

Some types of costs would be incurred only by operators of newly produced airplanes in part 121 service. Other types of costs would be incurred by manufacturers of transport category airplanes and their operators, irrespective of the Federal Aviation Regulation part number under which they operate.

Insulation Material Unit Costs and Weights

Insulation material costs are a function of the size of the airplane and its thermal and acoustical needs, which, in turn, depend on the configuration of the airplane, its performance characteristics, and its utilization. Based on dimensional, material weight, and cost information received from airplane manufacturers, air carriers, and insulation blanket manufacturers and the results of testing by the FAA's Technical Center, the FAA has determined that some materials that would meet the proposed test requirements cost no more and weigh no more than materials currently being installed in newly-produced airplanes. Because the proposed rule would apply to newly-produced airplanes (i.e., no planes would be removed from service for retrofit), only the incremental costs of these improved blankets and engineering costs to effect any design changes are attributable to the rule.

The FAA estimates that insulation blankets currently installed in transport category airplanes are composed of an average of three inches of fiberglass batting covered with a film. Under the proposed requirements for affected part 121 airplanes with 20 or more passenger seats, the FAA assumes that the blankets in the lower half of the fuselage would be composed of an average of two inches of fiberglass batting and one inch of Curlon® batting (a material that would meet the proposed requirements for burnthrough protection) and the blankets in the upper half would be composed of an average of three inches of fiberglass.[5] Blankets would be enclosed in metalized PVF; a film shown to meet the proposed flame propagation requirements. Because the proposed rule would not require burnthrough protection for airplanes with fewer than 20 passenger seats, the FAA expects that those airplanes would continue to have an average of three inches of fiberglass batting covered with metalized PVF film.

In estimating these costs, the FAA made the following assumptions:

- Fiberglass costs $0.50 per square foot, one inch thick;
- Curlon® costs $1.80 per square foot, one-inch thick;
- Fiberglass and Curlon® weigh the same;
- Metalized PVF costs $0.22 per square foot;
- Film currently being installed on newly-produced airplanes also costs $0.22 per square foot and weighs the same as the metalized PVF in this analysis;
- On average, 3 layers of batting will be used throughout the fuselage;
- The amount of material purchased exceeds the amount used by 15% to account for waste in the fabrication process; and
- Pre-fabricated shipsets cost twice as much as the raw materials to make them.

Other materials may also be used, but these may be more expensive or add substantial weight to the blankets. The FAA solicits information concerning the materials that would be used to comply with the proposed requirements.

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[5] Curlon® would be installed on the outboard side, next to the fuselage, for burnthrough protection.

In this analysis, the FAA has assumed that substituting one inch of fiberglass with Curlon® would not significantly affect the acoustical characteristics of the insulation in the affected area of the airplane. The FAA also requests information on the acoustical characteristics of Curlon® vis a vis fiberglass.

Based on the assumptions listed above, there would be no incremental cost (for either materials or weight) of installing insulation in airplanes with fewer than 20 passenger seats, because some materials that are currently used would meet the proposed requirements for flame propagation. For airplanes with 20 or more passengers, the additional cost would be that of replacing one inch of fiberglass with one inch of Curlon®.

Part 121 Airplanes Produced between 2000 and 2019

In order to determine the number and types of transport category airplanes operating under part 121 that will be added to the U.S. fleet during the years 2000 – 2019, the FAA reviewed its own forecast as well as those of Boeing and Airbus.[6] The FAA estimated the number of airplanes that would be affected by the proposed rule and manufactured between 2000 and 2019.[7] [8] Based on these forecasts, the FAA developed four airplane categories as proxies to represent these new airplanes. These airplane categories, which include airplanes produced under new certifications, are: 1)

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[6] U.S. Department of Transportation, Federal Aviation Administration, Office of Aviation Policy and Plans. Aerospace Forecasts Fiscal Years 1999-2010. FAA APO-99-1. Washington, DC.
Airbus Industrie. The Airbus Global Market Forecast 1998 –2017. Blagnac Cedex, France.
The Boeing Company. Current Market Outlook – 1999. Seattle, Washington.

[7] These estimates include airplanes produced under new type certificates.

[8] Included in these estimates are newly-produced airplanes that may be used in part 125 service. The FAA expects that, although there would be no burnthrough requirements for part 125 airplanes, manufacturers would install insulation providing burnthrough protection in these airplanes as well. The costs of burnthrough protection to part 125 airplanes, although not required, is included in these estimates.

2-engine narrowbody airplanes with 20 seats or more; 2) 2-engine widebody airplanes with 20 seats or more, 3) 2-engine widebody airplanes with 19 or fewer seats (i.e., cargo airplanes); and 4) 4-engine widebody airplanes with 20 seats or more. These estimates are conservative in that they likely overestimate the number of airplanes. It should be noted that, under these assumptions, all 2-engine narrowbody airplanes and all 4-engine widebodied airplanes, because they have 20 or more seats, would require burnthrough protection under the proposed rule. Two-engine widebody airplanes with 20 or more seats would also require burnthrough protection.

Table 1 presents the number of airplanes affected by the proposed rule for the years 2000 – 2019. Of these estimated 10,943 newly produced N-registered airplanes expected to join the U.S. fleet during that 20-year period, 8,781 would be required to have fuselage burnthrough protection. (The estimated 2,162 newly-produced airplanes with fewer than 20 seats would be exempt from this proposed requirement.)

Table 2 summarizes the costs for improved insulation for these 8,781 airplanes. Table 2 shows that the total discounted costs over 20 years are $52.6 million, or $22.6 million discounted to present value at seven percent. The annualized cost over 20 years is $2.1 million.

Engineering Costs

Manufacturers would incur costs of changing installation drawings and production part numbers for the new insulation blankets of newly produced currently certificated airplanes. There would be no costs attributable to the proposed rule for airplanes of new type designs, because the proposed engineering costs are for changes to drawings. Estimates of the time to accomplish these changes are a function of the size of the airplane and whether or not the blanket configuration would have to be changed. The FAA received estimates from a variety of sources of the number of hours that would be needed to change part numbers and drawings. The FAA acknowledges that the process of accomplishing these tasks involves a series of steps, including changing the drawings (part numbers and, when necessary, blanket configurations) and reviews and approvals by various groups (e.g., engineering, weight and balance, stress, and other groups).

The FAA estimates that there would be 15 models of currently certificated airplanes in operation under part 121 at the time the proposed rule would be effective. As described above, for purposes of estimating costs, there would be two-engine narrowbody airplanes (six models), two-engine widebody airplanes (six models, two of which are cargo models), and three four-engine widebody airplanes. The FAA estimates the burdened hourly rate for an engineer employed by a manufacturer of large transport category airplanes is $130. Table 3 presents the FAA's estimate of the range of costs to effect the insulation blanket changes. If only blanket materials change, the estimated costs would total $13.8 million. If configurations also change, that is, if the method of fastening blankets to the fuselage or to each other (such as overlapping adjacent blankets on stringers), Table 3 shows that the estimated costs would be $48.9 million. These costs would occur in the first two years after the effective date of the rule. Discounted costs, assuming half the cost would be incurred in 2000 and half in 2001, would range from $12.5 million to $44.2 million.

The FAA solicits information and comments concerning the engineering costs to part 121 airplane manufacturers, including information concerning the need for blanket configuration changes.

Because airplane models operated under part 125 are typically the same airplane models that are operated under part 121, there would be no additional engineering costs to those models.

Manufacturers of other transport category airplanes, that is, those operating under parts 91 or 135, would also incur engineering costs. These costs would be considerably less than those for part 121 airplanes because, in many cases, the FAA expects insulation blanket fabricators, rather than manufacturers, would provide material specifications and revised installation drawings. Because the proposed requirements for parts 91 and 135 do not include burnthrough, the engineering costs would be those for material, but not configuration, changes.

The FAA estimates that there are about 25 currently produced different series of models of transport category airplanes operating under parts 91 and 135. In addition, about 25 different series of models of transport category airplanes operating under parts 91 and 135 are no longer in production. There is substantial commonality among different series of the same model (e.g., the Learjet LR-35A and the Learjet LR-36A). Because of this commonality, the FAA estimates that drawings showing material changes for an equivalent of 25 models (half for airplanes in current production and half for airplanes not in current production, but in current service) would be required and that it would take 300 hours per model to make these changes. The FAA also estimates that the burdened hourly rate for an engineer is $100 per hour, less than the $130 per hour for an engineer employed by a manufacturer of large transport category airplanes.

Table 4 presents the estimated costs for engineering costs to effect insulation blanket changes for parts 91 and 135 airplanes. Total nondiscounted costs are $750,000, or $678,007, assuming the costs are distributed equally over the years 2000-2001.

Testing Equipment

Manufacturers of insulation blankets or blanket components would incur costs to test blankets or blanket components.  Two tests are proposed:  a flame propagation test and a burnthrough test.

The flame propagation test (also called the critical radiant flux test) is based on a test method developed for floor-covering systems, Standard Test Method ASTM E 648 for

Critical Radiant Flux of Floor-Covering Systems using a Radiant Head Energy Source. The FAA's Technical Center has modified the test method for purposes of measuring flame propagation on insulation materials.  A rig that is used for ASTM E 648 testing costs about $50,000.  For purposes of this analysis, the FAA conservatively estimates these modifications would cost an additional $10,000.  The FAA expects that airplane manufacturers, insulation blanket fabricators, and chemical company manufacturers would purchase or construct 12 of these modified rigs.  The costs, therefore, would be $720,000.  The FAA assumes that these costs would be incurred in the first year of the rule.  Based on the assumption that the proposed rule would become effective in the year 2000, the costs of flame propagation testing equipment would be $673,000 discounted to present value.

The proposed burnthrough test was developed by the FAA's Technical Center.  The equipment would include a gun-type test burner that uses kerosene for a fuel source and various components that measure heat flux, temperature, air velocity, and time. The test rig would be provided with an exhaust system to remove combustion products.  The FAA estimates that the test apparatus would cost about $10,000. Again, the FAA expects that airplane manufacturers, insulation blanket fabricators, and chemical companies would purchase 12 rigs.  The costs, therefore, would be $120,000 for 12 rigs, or $112,000 discounted to present value. Manufacturers currently have facilities and personnel that conduct blanket certification testing, therefore, the FAA has attributed no other costs to testing materials. Table 5 presents the costs for testing equipment.

<u>Total Costs of the Proposed Rule</u>

Table 6A presents the estimated total costs of the proposed rule over the years 2000 – 2019, assuming no configuration changes are made to the insulation blankets (i.e., the engineering costs are those associated only the blanket materials). Table 6A shows that the total costs over the years 2000 – 2019 are $68.0 million, or $36.5 million discounted to present value. Improved insulation material costs account for about 77 percent of total nondiscounted costs, while engineering costs account for 21 percent and testing equipment accounts for one percent.

If manufacturers need to make configuration changes as well as material changes to their drawings, Table 6B shows that the total costs would be $103.1 million over the years 2000 – 2019, or $68.2 million discounted to present value. In this scenario, engineering costs account for 51 percent of total nondiscounted costs, improved insulation material costs account for 48 percent, and testing equipment accounts for one percent.

In both scenarios, the greatest costs would be incurred during the first two years after the effective date, when airplane and insulation blanket manufacturers and testing labs would incur costs. Distributing total nondiscounted costs over the estimated number of N-registered transport category airplanes produced from 2000-2019 shows that the per airplane costs of this proposed rule would range between $6,218 and $9,419.

## IV. BENEFITS OF THE PROPOSED RULE

On September 2, 1998, Swissair Flight 111 crashed off the coast of Nova Scotia, Canada, with a loss of 229 lives. Although the Transportation Safety Board of Canada has not released its report of the probable causes of the Swissair accident, preliminary evidence points to burning thermal/acoustic insulation above the cockpit ceiling as contributing to the crash. The airplane, a McDonnell Douglas MD-11, used insulation blankets composed of fiberglass covered with metalized Mylar®. The FAA has determined that replacement of metalized Mylar® is necessary and is proceeding to address the affected material by airworthiness directive.

There have been other reports of fires in which the flammability of the thermal/acoustical insulation was a contributing factor. Several of these events are described below.

<u>SAS DC-9 MD-87, November 24, 1993</u>

On November 24, 1993, an MD-87, registration SE-DIB, operated by SAS with 85 passengers and crew suffered extensive damage as a result of a fire that originated in an aft stowage closet.[9] Continuing electrical arcing of wires providing lights in the stowage closet ignited the cabin sidewall insulation material, which was covered with metalized Mylar®. The fire "eventually developed into a fierce, <u>for the crew uncontrollable</u> fire which subsequently destroyed the aft part of the cabin interior and a major part of the aircraft structure."[10] [Emphasis added.] Fortunately, ignition and the resulting fire developed after landing. The fire destroyed major parts of all the equipment installed in the aft right-hand side of the cabin (e.g., stowage bins, three

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[9] Aircraft Accident Investigation Board of Denmark, "Aircraft Accident Report, DC-9 MD-87, SE-DIB, Copenhagen Airport Kastrup, 24 November 1993."
[10] <u>Op. cit.</u>, p.2.

rows of seats, wiring and ventilation ducting), destroyed the fuselage skin and structure over a large area on the right side of the aircraft, and severely damaged the entire cabin's furnishings. The cockpit voice recorder (CVR) indicated that about six minutes passed between the first indication of burning and evacuation of the airplane. The airport fire vehicles and the county fire brigade brought the fire under control within about 15 minutes and extinguished the fire about two hours later.

In its report the Danish Aircraft Accident Investigation Board (AAIB) complimented the crew for its professional, orderly evacuation of the airplane, but stated that it believed "it would have been very difficult – if not impossible – to extinguish the fire … had the fire occurred in the air."[11]

SE-DIB had been the first of the company's 16 MD-87's,, which had undergone a "midway (12,500 flight hours)" inspection 19 days before the accident. As a result of this fire, SAS's Company Investigation Team (CIT) and the AAIB participated in the inspection of three additional MD-87's when those airplanes were due for disassembling and inspection. Improper routing of wires was noted in all three aircraft. In addition, large amounts of dust had accumulated behind and inside floor level ventilation grills and on and behind insulation blankets. The AAIB concluded that this accumulation of dust was a potential source of fuel for a fire. However, the AAIB also noted that SE-DIB had been thoroughly cleaned during its inspection 19 days before the accident, dust was "not considered to have been a factor in the accident."[12]

On August 9, 1996, McDonnell Douglas released an All Operator Letter (AOL), which applies to all DC-8, DC-9, MD-80, MD-90, DC-10, and MD-11 operators.[13] The AOL recommended that operators discontinue use of metalized Mylar® blanket covering

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[11] Op. cit., p. 34.
[12] Op. cit., p. 33.
[13] McDonnell Douglas Corporation, Product Support. All Operator Letter, August 9, 1996.

material and tapes and recommended a more stringent set of test conditions to determine blanket flammability characteristics.

See the Appendix for pictures of the SAS DC-9 involved in this accident.

<u>Canadian Airlines DC-10, Amsterdam, Netherlands, April 10, 1989</u>

On April 10, 1989, a Canadian Airlines DC-10, registration C-FCRA, operating as a scheduled passenger flight, landed at Schiphol Aeroport in Amsterdam, Netherlands. About two hours later, after the aircraft had been towed to another bridge, cleaning crews discovered a fire overtop the aft starboard lavatory ceiling.[14] Firefighters arrived to find the cabin completely full of dense smoke. Two firefighters donned self-contained breathing apparatus and used two six-kilogram Halon fire extinguishers to extinguish the flames. They also sprayed 50 liters of water in a mist to cool down the area, while other firefighters positioned fire trucks on either side of the tail and sprayed water on the fuselage to cool it.

The Canadian Transportation Safety Board (TSB) and Douglas Aircraft Corporation (DAC) conducted an investigation into the cause of the fire. The exterior starboard fuselage skin was scorched and buckled for about 10 inches up to the level of the #3 engine pylon. The heaviest damage to the interior of the aircraft occurred to the ceiling area in front of and directly above the starboard lavatory. The fire consumed the upper section of the lavatory doorframe, the foam between the doorframe and the ceiling, and 50 cm. of a side panel. The insulation blankets in the vicinity of the R4 passenger door were destroyed in the fire. Two light fixtures in the galley were damaged, as was an oxygen panel that contained an oxygen generator. (The oxygen generator was

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[14] Attachment to a letter from J.E. Foot, Electrical/Mechanical Analysis Engineer, Canadian Aviation Safety Board, to Ed Chalpin, FAA/Mechanical Systems, April 25, 1989. The attachment is labeled "draft."

activated and may have produced an oxygen-enriched atmosphere for about 15 minutes.) The fire was hot enough to melt aluminum, which has a melting point of 1217° F: resolidifed aluminum, presumably from the melting of the overhead light fixture, was fused into the flooring material.

DAC examined and tested the aluminized Tedlar® covering of the insulation blankets in the vicinity of the aft L4 door (the blankets near the R4 door were destroyed and could not be tested). These blankets and patching and joining tapes appeared contaminated or stained with a greasy substance. The contamination on the tapes was determined to be Aero Shell 7, a lubricant used on door drive chains. The remaining stains were not identified. DAC tested a sample of new covering material, as well as samples of sooted covering and stained covering from the aircraft.[15] None of the samples supported continued combustion or produced hot drippings when the flame was removed. However, when samples containing contaminated tapes were tested, all samples continued to burn from between 13 and 173 seconds after removal of the flame. In addition, some of these samples produced drippings that continued to burn from between 3 and 120 seconds.[16]

DAC issued a Service Bulletin (SB) 25-350 in 1988 to address the problem of electrical arcing of the overhead light assembly terminals in DC-10's. The SB resulted from reports by operators that electrical shorting and flames were observed coming from insulation blankets above the light assembly. The SB called for the application of a sealant over the terminal caps of the fixture to prevent accumulation of conductive contaminants, which could cause arcing between the lampholders and the fixture. Examination of the fixtures in this aircraft showed that the fixtures were sealed but

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[15] DAC used the vertical burn test, which requires a Bunsen burner be placed directly under the edge of a suspended sample for 12 seconds. The sample should not support continued combustion upon removal of the flame.
[16] Op. cit., p. 13.

arcing had still occurred. "A fleet check by CAI found other sealed lampholders that also exhibited arcing damage."[17] Examination of the lampholders revealed cracks in the body of the holders that may allow for the accumulation of conductive contaminants that aid in the formation of an electric arc. Lampholders were redesigned and on September 5, 1989, DAC issued SB 25-357 that called from replacement of existing with newly designed lampholders. The FAA issued AD 90-04-03 in 1990, mandating compliance with SB 25-357.

The report of this incident states that "Although this arcing may cause some charring of the fixture and of the lampholder it appears highly unlikely that this alone would initiate a fire."[18] The report also notes that an insulation blanket that had been in contact with a lampholder (with unsealed terminal caps) on another aircraft had burned. Although the report does not state a positive determination of the cause of the fire, it does state that "the most likely source of heat ignition was arcing at one of the light fixture lampholders while in contact with an insulation blanket. This may have resulted in flames spreading to a section of blanket contaminated with Aero Shell 7 or the blanket in contact with the lampholder may have been contaminated."[19]

Alitalia MD-82, Turin, Italy, November 26, 1995

An Alitalia MD-82 experienced smoke and fumes in the aft cabin while waiting for take-off. Twenty-seven passengers and six crewmembers evacuated the airplane through a forward door via the emergency slide. No injuries were reported. The fire department used powder, foam, and water to estinguish the fire.

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[17] Op. cit., p. 16.
[18] Op. cit., p. 18.
[19] Op. cit., p. 19.

The source of the fire was a Day-Ray light ballast. The metalized Mylar® (ORCOFILM AN-43) covering of the insulation blanket burned for an area of 5 by 1.5 meters within the ceiling of the passenger cabin.[20] Ceiling panels forward, adjacent, and aft of the left overwing area were found burned. There was external skin damage from fuselage burnthrough. In a letter to the National Transportation Safety Board, the Italian investigator reported that, "when we expose an insulation blanket (without conditioning) to a little flame and for less than 2 seconds, to simulate the same configuration that is visible over the overhead storage compartment in proximity of the Day-Ray ballast, we can always observe that the insulation covering burns quickly and the flames generated by it burns the adjacent and overhanging insulation covering."[21] Although the duration of the flames from the ruptured ballast could not be determined, the investigator stated that "… even a little flame at not more than 1550° and lasting approximately less than 2 seconds would have been sufficient to ignite the insulation covering ORCOFILM AN-43 DMS 2072K TYPE 2 CLASS 1 GRADE A …."[22] The investigator concluded that "…the insulation covering ORCOFILM AN-43 may be considered a vehicle for the flame and it was the material responsible for the aircraft fire incident …[23]

<u>China Air B737-300, Beijing, China, October 19, 1994[24]</u>

After landing, ground crews boarded the airplane for maintenance. Noticing a smell of smoke, the crews opened the electrical and electronics bay (E/E bay) and found an

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[20] Letter from Giuseppe Spinelli, Investigator in charge, Repubblica Italiana, Ministero Dei Transporti E Della Navigazione, to R. G. Rodriguez, National Transportation Board, May 28, 1996.
[21] <u>Op. cit.</u>, p. 4.
[22] <u>Op. cit.</u>, p. 2. ORCOFILM AN-43 is a tradename for metalized mylar.
[23] <u>Op. cit.</u>, p.3.
[24] Investigation Report of the Electric Room Fires on the B-737 and MD-11. Technical Report. Civil Aviation Administration of China, Aircraft Airworthiness Centre. Attachment to a letter from Wu Xiangru, Director of CAAC-AAD, to the FAA's Aircraft Certification Office, Renton, Washington, June 24, 1996.

insulation blanket on fire. The Chinese reported that a metal wire bundle clamp made contact with the wires, which had lost their insulation. The sparks from the resulting short circuit ignited the blanket. This airplane had been delivered in January 29, had completed 2,287 cycles, and the insulation had not been replaced. Although the Chinese did not report the extent of the damage to the airplane, they estimated the cost of the loss was US $500,000. The report did not identify the insulation covering material.

<u>Yunnan Airlines B737-300, China, November 13, 1995</u>[25]

During a “C” check, maintenance personnel used an air drill to remove a “floor nut bolt” of a cargo door. The chips of the bolt ignited the insulation blanket under the floor, resulting in a scorched hole 18 by 40 inches. The report did not identify the insulation covering material.

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[25] Op. cit.

China Air MD-11, Capital Airport, China, September 6, 1995[26]

Prior to starting engines, the flight crew discovered a fire in the E/E bay. Vibration of wires that were not secured by a wire clamp had resulted in a short circuit. Eleven of the wires were separated by fire and the metal droppings ignited the insulation blanket under the E/E bay. Although the report does not indicate the type of insulation covering material or the dimensions of the burned insulation, it appears that a significant area was burned. The report does note that the burning area approached the bottle of oxygen for the flight crews.

World Airways MD-11, San Bernardino, California, discovered March 29, 1999[27]

During a scheduled “4 C” check, maintenance personnel discovered a burned insulation blanket in the aft cargo bay when they removed the floorboards for inspection. A wiring harness was routed across and onto a frame in the area. One of the harness’ wires was separated and the insulation of seven other wires were damaged and chafed where they contacted the frame. Evidence of wire chafing and arcing was present on the wire bundle and the frame where the bundle contacted it. The metalized Mylar® that covered the insulation blanket of approximately 60 by 20 inches had completely burned away, exposing partially burned insulation material beneath it. A 1.25-inch hole in the blanket was found underneath the chafed portion of the wire bundle. The bundle emanated from the aft cargo loading system control box. Although the time and circumstances of the fire were unreported and are unknown, a deferred maintenance item dated February 22, 1999, was noted in the aircraft logbook that reported an inoperative electric cargo loading system.

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[26] Op. cit.
[27] National Transportation Safety Board. Preliminary Report Aviation. NTSB ID: DCA99SA051.

See the Appendix for pictures of the damage to this airplane.

Continental B737-200, Cleveland, Ohio, April17, 1988

While on final approach, smoke and flames developed in the cabin above overhead luggage bins. The crew declared an emergency, landed, and evacuated the aircraft. A ceiling fluorescent light ballast had shorted, igniting foam insulation surrounding the air duct, and burning the bins, wire bundles, approximately five square feet of insulation film, and carry-on bags in the bins. There were two minor injuries among the 108 passengers and crew aboard the airplane.

See the Appendix for pictures of the damage to this airplane.

UTA B747, Charles de Gaulle Airport, France, March 16, 1985

A fire started in the forward cargo compartment of a UTA (French charter airline) Boeing 747 while it was being cleaned. The cleaning crew attempted to extinguish the fire, but was unsuccessful and exited the aircraft. The fire burned the thermal/acoustical insulation, moved up the sidewalls into the main and upper deck of the forward fuselage B747, and destroyed the airplane. The fire was eventually brought under control by the fire department. No ignition source was determined, although investigators speculated that a burning cigarette may have started the fire.

See the Appendix for pictures of the damage to this airplane.

Air Canada DC-9-32, Covington, Kentucky, June 2, 1983

While enroute at Flight Level 330, the cabin crew discovered a fire in the aft lavatory. The flight crew made an emergency descent and landed at Greater Cincinnati International Airport. After the crew stopped the airplane, fire department personnel moved in and began fire-fighting operations. Occupants began evacuating the aircraft, but about 60 to 90 seconds after the exits were opened, a flash fire enveloped the interior of the aircraft and 23 passengers who were unable to exit the aircraft died. An investigation revealed that three flush motorcircuit breakers had popped about 11 minutes before smoke was detected.

Many regulatory changes occurred as a result of this accident. Included were fire blocking, a requirement for floor proximity lighting, overload protection on flush pumps, and a requirement for smoke detectors. However, no changes were required regarding the thermal/acoustical insulation, which spread the fire.

See the Appendix for pictures of this accident.

The accidents and incidents described above indicate that the flammability of the thermal/acoustical insulation can be a significant factor in contributing to the spread of a fire, either inflight or after a crash. The proposed rule would reduce those threats by requiring newly produced airplanes to use improved insulation that passes the proposed requirements for flame propagation and fuselage burnthrough.

The FAA, in conjunction with the Civil Aviation Authority of the United Kingdom (UK) and the Direction Generale de l'Aviation Civile (DGAC) of France, conducted research to assess the current capability of airplane fuselages to resist burnthrough from an external fuel fire. That research demonstrated the importance of thermal/acoustic insulation in the burnthrough process.[28] [29] Without making any other change to the airplane, these studies showed that improved thermal/acoustic insulation can delay the entry of a post-crash fuel fire by several minutes, thus prolonging the time available for

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[28] Department of Transportation, Federal Aviation Administration. "Fuselage Burnthrough from Large Exterior Fuel Fires," Federal Aviation Administration Final Report DOT/FAA/CT-90-10. July 1994.
[29] Civil Aviation Authority. "Burnthrough Resistance of Fuselages: Further Investigation," CAA Paper 95003. London. 1995

escape. Although there are other factors that affect fuselage burnthrough, it was demonstrated that the simplest and most effective approach to improving burnthrough protection was to improve the fire resistance of the insulation.

A study by R.G.W. Cherry & Associates Limited[30] examined the International Cabin Safety Research Technical Group's Survivable Accidents Database to identify and extract data for aircraft accidents where fuselage burnthrough was an issue in the survivability of the occupants. A burnthrough accident was defined as: "An aircraft accident where the fuselage skin was penetrated by an external fire while live occupants were on board."[31] A survivable accident is one "where there were one or more survivors or there was potential for survival."[32] Only survivable or potentially survivable accidents in which there were fire injuries were selected for analysis.

Seventeen accidents involving 2,201 occupants and occurring between 1966 and 1993 were identified by Cherry & Associates. In analyzing accidents, Cherry & Associates estimated fatalities and injuries that might have been avoided if the aircraft had been configured to later requirements. These later requirements were:

- Floor proximity lighting/marking;
- Seat blocking layers;
- Fire hardening of cabin interior materials; and
- Improved access to type III exits.

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[30] R.G.W. Cherry & Associates Limited. "Fuselage Hardening for Fire Suppression: Safety Benefit Analysis based on Past Accidents." Issue 2. Hertfordshire, England. October 1998.
[31] Op. cit., p. 8.
[32] Op. cit., p. 8.

Cherry & Associates derived benefits based on the aircraft standards at the time of the accident and on aircraft assumed to be configured to later requirements.[33] Because the proposed rule would apply to newly produced airplanes, the results based on later requirements are those used in the FAA's benefits analysis.

Of the 140 worldwide fire related fatal accidents in the International Cabin Safety Research Technical Group's Survivable Accidents Database at the time of Cherry & Associate's study, only 54 percent had sufficient data to assess whether burnthrough occurred. Assuming the accidents that did not have sufficient data have a similar benefit potential to those that do, the actual benefits would be 1.85 times (1/0.54) the analyzed benefits.

The FAA's Technical Center has determined that the burnthrough protection requirements of this proposed rule would provide an additional four minutes of time for occupants to exit an airplane. Cherry & Associates' analysis shows that an additional four minutes would result in 10.1 lives saved per year worldwide.[34] Because this proposed rule would apply only to newly produced airplanes of U.S. registry, the FAA has adjusted this estimate downward.

The Cherry report states that the authors do not believe that "… the number of fatalities and injuries will change markedly for the near future."[35] The FAA disagrees. Based on FAA and industry forecasts, the number of transport category passenger airplanes in the world fleet is expected to grow by 109 percent over the years 2000 – 2019, while the number of airplanes in the U.S. fleet is expected to grow by 97 percent. The

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[33] Kevin Warren, R.W.G. Cherry & Associates. Personal communication with Marilyn DonCarlos, January 1999. For purposes of determining benefits of "later requirements," Cherry & Associates used a date of 1990.

[34] R.G.W. Cherry & Associates Limited, p. 23.

[35] Op. cit., p.5.

number of passengers enplaned by U.S. carriers is expected to grow by 107 percent. Therefore, the FAA has estimated that Cherry's estimate of 10.1 lives saved per year would increase by about 2.157 percent per year or by 50 percent by 2019.

Table 7 presents the FAA's estimate of the number of fatalities that would be avoided by the proposed rule's requirement for burnthrough protection. A total of 37.2 fatalities would be prevented over that time. Assuming society is willing to pay $2.7 million to avoid a fatality, burnthrough protection for the newly produced airplanes in the U.S. fleet would result in a nondiscounted total benefit of $100.5 million over the 20-year period, or $37.7 million discounted to present value.

There would also be benefits from the proposed flame propagation requirement. As several of the incidents and accidents described above show, the potential for ignition from electrical arcing or other sources can be high. The proposed flame propagation requirements would ensure that, if ignition occurred, the resultant flame would not spread on the thermal/acoustic insulation.

The FAA is unable to quantify the benefits from the flame propagation requirement. However, preventing the loss of one airplane and its passengers over the 20-year period is not unlikely, as the incidents described above show. Assuming such a loss would occur at the midpoint of the analysis, or in 2009, with 169 passengers,[36] the nondiscounted loss would be $455.5 million, or $231.5 million discounted to present value (again, assuming society's willingness to pay $2.7 million to avoid a fatality). This loss does not include the value of the airplane. Even without loss of life, as several of the incidents described above show, a hull loss could exceed tens of millions

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[36] U.S. Department of Transportation, Federal Aviation Administration, Office of Aviation Policy and Plans. Table 6. The average number of seats in U.S. air carrier aircraft is forecast to be 168.7 in 2009.

of dollars.  The FAA, therefore, has determined that this proposed rule would be cost beneficial.

## V. REGULATORY FLEXIBILITY DETERMINATION AND ANALYSIS

The Regulatory Flexibility Act of 1980 (FRA) establishes "as a principle of regulatory issuance that agencies shall endeavor, consistent with the objective of the rule and of applicable statutes, to fit regulatory and informational requirements to the scale of the businesses, organizations, and governmental jurisdictions subject to regulation." To achieve that principle, the RFA requires agencies to solicit and consider flexible regulatory proposals and to explain the rationale for their actions. The RFA covers a wide-range of small entities, including small businesses, not-for-profit organizations and small governmental jurisdictions.

Agencies must perform a review to determine whether a proposed or final rule will have a significant economic impact on a substantial number of small entities. If the determination is that it will, the agency must prepare a regulatory flexibility analysis (RFA) as described in the RFA. However, if an agency determines that a proposed or final rule is not expected to have a significant economic impact on a substantial number of small entities, section 605(b) of the 1980 act provides that the head of the agency may so certify and an RFA is not required. The certification must include a statement providing the factual basis for this determination, and the reasoning should be clear.

The FAA conducted the required review of this proposed rule. The engineering costs would be incurred by manufacturers of transport category airplanes, none of whom is a small entity. Testing equipment costs would be incurred by airplane manufacturers, insulation blanket fabricators, and chemical companies. The FAA has determined that none of these entities that are expected to conduct testing are small. Finally, the cost of a newly produced passenger airplane outfitted with burnthrough protection would be greater because of the proposed rule. The FAA cannot determine who would purchase these airplanes, but the incremental cost of burnthrough material protection would not exceed $11,000 (in a four-engine widebody), an amount that would represent less than one-tenth of one percent of the total cost of a new airplane.

Accordingly, pursuant to the Regulatory Flexibility Act, 5 U.S.C. 605(b), the Federal Aviation Administration certifies that this proposed rule will not have a significant economic impact on a substantial number of small entities.

## VI. INTERNATIONAL TRADE IMPACT ASSESSMENT

The provisions of this proposed rule would have little or no impact on trade for U.S. firms doing business in foreign countries and foreign firms doing business in the United States.

## VII. UNFUNDED MANDATES REFORM ACT

Title II of the Unfunded Mandates Reform Act of 1995 (the Act), enacted as Pub. L. 104-4 on March 22, 1995, requires each Federal agency, to the extent permitted by law, to prepare a written assessment of the effects of any Federal mandate in a proposed or final agency rule that may result in the expenditure by State, local, and tribal governments, in the aggregate, or by the private sector, of $100 million or more (adjusted annually for inflation) in any one year. Section 204(a) of the Act, 2 U.S.C. 1534(a), requires the Federal agency to develop an effective process to permit timely input by elected officers (or their designees) of State, local, and tribal governments on a proposed "significant intergovernmental mandate." A "significant intergovernmental mandate" under the Act is any provision in a Federal agency regulation that would impose an enforceable duty upon State, local, and tribal governments, in the aggregate, of $100 million (adjusted annually for inflation) in any one year. Section 203 of the Act, 2 U.S.C. 1533, provides that before establishing any regulatory requirements that might significantly or uniquely affect small governments, the agency shall have developed a plan that, among other things, provides for notice to potentially affected small governments, if any, and for a meaningful and timely opportunity to provide input in the development of regulatory proposals.

This proposed rule does not contain any Federal intergovernmental or private sector mandate. Therefore, the requirements of Title II of the Unfunded Mandates Reform Act of 1995 do not apply.